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Using Crop Residues on Soils of the Humid Area

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U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

The Department of Agriculture and the State agricultural experiment stations are moving ahead with new research programs on crop residue management and tillage practices. It will pay you to keep in touch with this research work by consulting your county extension agent and the technicians of your soil conservation district. They can give you more detailed information about the practices described in this bulletin. They may know of farmers close to you who have tried the tillage practices.

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Using Crop Residues on Soils of the Humid Area

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Many crops grown in the Eastern United States produce considerable plant materials in addition to the harvested or grazed parts. These plant materials are usually left in the field until the planting of the next crop, when they are returned to the soil through various tillage operations for seedbed preparation (figs. 1 and 2). If these plant residues are utilized properly, they contribute immensely to the maintenance and increase of the ever-dwindling soil organic matter and to the reduction of runoff and soil erosion.

Tillage methods for handling large quantities of plant residues have been a difficult problem for many years. The residues slowed seedbed preparation and planting by raking and "balling up" in front of the plows and planters. Until

[1] Most of the studies referred to in this bulletin and used as the bases for the recommendations given herein were conducted in cooperation with the Iowa and South Carolina Agricultural Experiment Stations.

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Figure 1.—Cover crops planted between rows of crops offer possibilities for returning large quantities of residues to the soil. By the following spring this rye-vetch cover crop will produce several tons of dry matter.

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Figure 2.—**This rye-vetch winter cover crop in South Carolina followed corn. A winter cover crop such as this will provide several tons of organic material.**

recently, the common practice was to burn crop residues, and in some sections of the Southeast today farmers burn grain straw before planting soybeans. Some farmers objected to adding or leaving straw residues on the land as a mulch, because the residues retarded plant growth and development. These and other objections to plant residues on the land have been resolved to some extent through development of new tillage machinery, the addition of fertilizers, use of weed control chemicals, and use of different systems of management.

Plant residues may be plowed under, left on the soil surface, or partially mixed in the soil surface in preparing the seedbed for the next crop (mulch tillage). Residues handled by any of these systems will reduce runoff and erosion caused by water and wind. When plant residues are used as a mulch, they provide maximum protection to the land; when incorporated in the soil, they provide less protection. Plant residues contain nutrients, which become available for plant use in varying amounts and rates as biological decomposition progresses. A mulch influences soil temperatures as a result of its reflecting and insulating effect. Organic material, generally, improves soil aggregation or granulation, increases total plant nutrients in the soil, and helps to develop a mellow soil of a high degree of tilth.

How Crop Residues Reduce Soil Erosion

During an intense rain the beating action of raindrops on a bare soil causes the soil particles to be detached from one another. As

the soil aggregates break down, the finer particles are fitted together by the sorting action of the water, which tends to seal the soil surface, and runoff results. The water runs over the surface of the soil, carrying the dispersed soil with it, and can cause severe erosion. Residues that are turned under or mixed with the soil help to bind separate soil particles together and thus the aggregates are more resistant to breakdown by rain or tillage machinery.

If the residues are left on the surface, the force of the raindrops is dissipated on the mulch and the water can soak into the soil without sealing the surface. As the dead residues are very absorptive, the mulch holds considerable water at the soil surface. Mulch mechanically retards the surface flow of water, which permits more time for the water to infiltrate the soil.

In the Midwest, erosion losses from fields where all cornstalk residues were left on the soil surface were reduced at least 50 percent of that where the cornstalks were plowed under. In a study at Urbana, Ill., soil loss on a bare loamy soil was 3,225 pounds per acre and that from a plot mulched with cornstalks was 205 pounds after an hour's rain of 1¾ inches. Water losses for the two plots were 82 and 14 percent, respectively.

Maximum erosion control is obtained by handling plant residues as mulches. The data shown in table 1 illustrate the effectiveness of plant residues, handled by different methods, in reducing runoff and erosion.

TABLE 1.—*Effect of plant residue management on soil and water losses*

State and soil type	Period	Average rainfall per period	Treatment	Average runoff per period	Average erosion per period
		Inches		*Inches*	*Tons/acre*
Ohio: Canfield silt loam, 10-percent slope.	July and August, 1950–53.	8. 11	Manure plowed under.	4. 3	5. 3
			Manure mulch [1]	1. 9	. 2
South Carolina: Cecil sandy loam, 8-percent slope.	Growing season, 1943–52.	22. 12	Cornstalks and cover crop plowed under.[2]	1. 5	1. 2
			Cornstalks and cover-crop mulch.[2]	. 6	. 4
			Cornstalks plowed under.[3]	3. 7	2. 8
Iowa: Marshall silt loam, 10-percent slope.	Annual, 1943, 1945–46, 1949.	31. 79	Residues plowed under.	2. 2	8. 1
			Residue mulch	2. 1	2. 5

[1] Applied at "layby" after second cultivation.
[2] Corn grown each summer after winter rye-vetch cover crop.
[3] Corn grown each summer, no cover crop.

How Crop Residues Influence Nutrient Availability

Much of the nutrients that living plants obtain from the soil remains in the unharvested and ungrazed parts of the crops and crop residues. Most of the nutrients are not immediately available for plant use. Micro-organisms, inhabiting the soil, decompose the plant residues, whether they are on the surface or incorporated with the soil. Bacteria, algae, fungi, nematodes, earthworms, and insects use the residues as foods or sources of energy. Chemical transformations take place as the materials are decomposed.

Materials containing nitrogen, phosphorus, sulfur, potassium, and other nutrients for use of living plants are released from the dead residues through action of the various kinds of organisms on the starches, sugars, proteins, and other compounds constituting the residues. Other substances produced and released during decomposition of the residues are waxes, gums, and resins that may help develop better soil structure.

The kind and size of residue material, soil moisture and temperature, nutrients available, and other factors influence the rate of decomposition. Soil moisture and temperature affect the speed of decomposition to a considerable extent. Soil micro-organisms will decrease their activity if soil moisture or soil temperature is extreme. Generally, temperatures in the South promote a high level of bacterial activity, and, if moisture is adequate, decomposition rates are very high. For this reason, soil organic matter is generally low in the South.

The quantity of nitrogen available for use by soil micro-organisms and frequently the stage of maturity of the plant materials also affect decomposition rates. About 30 pounds of nitrogen is required by the micro-organisms to decompose a ton of residue.

Residues that are turned under decompose more rapidly than those left on the surface. Turned-under residues are in contact with moist soil most of the time; whereas, mulches may become air-dry at intervals when organisms either die or move back into the soil where the moisture supply is greater. Residues that are chopped into small pieces decompose faster than large pieces, whether they are used as a mulch or are incorporated in the soil.

Most cultivated crops will yield 2 tons or more of dry crop residues per acre. Properly fertilized plants grown under normal conditions will produce good crop yields and provide quantities of residues in these ranges: Oat straw, $1\frac{1}{2}$ to 2 tons; corn stover, 2 to 4 tons; wheat straw, $1\frac{1}{2}$ to $2\frac{1}{2}$ tons; soybean leaves and stems, $1\frac{1}{2}$ to $2\frac{1}{2}$ tons; and barley straw, 1 to 2 tons per acre. However, soil moisture supply, soil fertility, weather conditions, and crop variety may cause an even wider range in quantity of crop residues.

The quantities of nutrients contained in the forage and unharvested parts of crops commonly grown vary considerably (table 2). The total nutrients per ton of cotton and grain crop residues are generally less than those of legume and grass crops. Corn stover left in the field after a 100-bushel corn harvest will equal about 3 tons of dry material per acre, which will contain about 54 pounds of nitro-

gen (N), 24 pounds of phosphate (P_2O_5), and 60 pounds of potash (K_2O). Unharvested alfalfa on the land in the spring before planting summer row crops may yield about 1 ton of dry material per acre. This material will contain approximately 48 pounds of nitrogen, 11 pounds of phosphate, and 45 pounds of potash.

The availability of nitrogen and phosphorus in the residues depends on bacterial decomposition. However, most of the potassium is readily leached from plant residues by rainfall.

TABLE 2.—*Nutrient content per ton of unharvested or ungrazed parts of plants above the ground usually returned to the soil* [1]

Crop	Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)
	Pounds	*Pounds*	*Pounds*
Barley	12	5	29
Oat	12	4	30
Rye	10	6	17
Wheat	14	3	23
Corn	18	8	20
Cotton	22	7	35
Soybean	12	9	25
Grasses	40	4	43
Alfalfa	48	11	45
Red clover	38	9	35
Sweetclover	36	9	33
Cowpea	62	12	45
Vetch	62	14	46
Ladino clover	60	13	60
Lespedeza	42	10	20
Fescuegrass-Ladino clover	61	17	62
Ryegrass-crimson clover	60	13	61

[1] Soil, fertility level, weather conditions, stage of maturity of the plant, and other factors can influence the nutrient content of these crops. Values shown reflect the averages for plants at the time of usual harvest. Generally, immature plants contain higher percentages of nutrients than mature plants.

In some areas crops planted on land where heavy residues are left (see fig. 2) frequently develop symptoms of nitrogen deficiency. These residues do not contain enough nitrogen for the micro-organisms during the decomposition process, and the organisms therefore use part of the available nitrogen in the soil or that supplied as fertilizer, thus depriving the growing plants of that supply of nitrogen. Fertilizer should be added to compensate for this nitrogen shortage in plant residues.

For example, oat straw contains only 12 pounds of nitrogen per ton and the micro-organisms require 30 pounds of the nutrient while feeding on the straw. If 2 tons of oat straw per acre are left on the land and a crop is planted immediately after oat harvest, as much as 36 pounds of nitrogen fer-

tilizer may be needed in addition to that required for the growing crop. Usually, there is some residual mineral soil nitrogen that will be used by the micro-organisms while decomposing plant residues. The additional nitrogen applied is not lost for plant use, but is only temporarily immobilized, or "tied-up," by the soil organisms.

Such legume crop residues as cowpea, vetch, clover, and lespedeza contain more than 30 pounds of nitrogen per ton. As these legume residues decompose much more rapidly than residues low in nitrogen, a considerable quantity of the total nitrogen contained in the residues will become available during the first season.

No special fertilizer problems are involved in the processes that make other nutrients available for plant use. Among the nutrients returned to the soil through mineralization of organic matter are phosphorus, potassium, calcium, magnesium, and sulfur.

How Crop Residues Improve Soil Tilth and Organic Matter

During the breakdown of crop residues by micro-organisms, gums, waxes, resins, lignins, and other organic compounds that are resistant to decomposition are formed. These compounds and the mycelium, mucus, and slime produced by the micro-organisms help bind soil particles together as granules, or aggregates. These aggregates are relatively water-stable. However, the beating action of intense rains will break them up by dispersing the soil. The soil aggregates are also destroyed mechanically by excessive plowing and tilling.

Aggregation of the soil is one of the most important benefits derived from proper utilization of plant residues. A soil, aggregated to a high degree, is light and mellow, easily tilled, well aerated, and has a high infiltration rate.

Although a high level of organic matter in the soil is usually associated with good aggregation, some soils that have a large amount of organic matter are not necessarily well aggregated. For instance, aggregates are not readily formed in sands and loamy sands. Also, very poorly drained soils may have a high organic matter content but have a low degree of aggregation. Medium-textured soils such as sandy loam, silt loam, and clay loam aggregate well when adequate quantities of plant residues supply the needed organic matter and when other factors are favorable.

Rate and degree of soil aggregation depend on maintenance of fresh organic matter, soil temperature and moisture, methods of handling the plant residues, and other factors. Mulch-tilled soils are better aggregated and probably more stable than soils where plant residues are plowed under. Soils under mulch tillage are partially protected from the beating action of the more intense rains, and the temperature and moisture conditions under the mulch are more conducive to the activity of micro-organisms.

How Crop Residues Affect Soil Temperature and Soil Moisture

Plant residues used as a mulch suppress soil heat gains during the day and heat losses during the night. A light-colored mulch will

also reflect some of the radiation from the sun. During the growing season, a bare soil in which residues have been incorporated has a higher temperature during the day and a lower temperature at night than a mulch-tilled soil. A 3-ton-per-acre mulch of grain straw reduced the soil temperature an average of 1.8° F. at the 4-inch depth during May and June on cornland in Iowa, and 1.3° on cornland in South Carolina during June, July, and August. This reduction in soil temperature may retard corn growth early in the season, but as the soil temperature rises the slight reduction will not affect corn growth and development except in northern areas.

Evaporation losses are generally reduced when plant residues are used as mulches in the Eastern States.

Farm Practices That Utilize Crop Residues

Mulch Tillage

Mulch tillage is a system that leaves most of the plant residues on the soil surface. This system has also been called "trashy farming" in some sections of the country. Loosening the soil to prepare a seedbed for the next crop is the primary operation of any tillage procedure. In mulch tillage the equipment loosens the soil sufficiently to plant the seed, but at the same time leaves the plant residues on the surface as a mulch.

Mulch-tillage equipment is as varied in design and operation as the soil types on which it is used. A machine that is satisfactory in the Midwest may not be satisfactory for use in the Southeast. Usually the conventional planting and cultivating equipment, with slight modifications, can be used.

The first operation in preparing a seedbed with mulch on the soil surface is to chop or cut up the residues from the preceding crop and kill the plants growing at this time (fig. 3).

Disk-harrowing with a heavy-duty tandem disk (fig. 2) will chop the plant residues, kill most of the growing plants, and loosen the soil to a depth of 2 to 3 inches. The residue may be chopped with a field chopper before disk-harrowing if conditions require it. One disk-harrowing usually will kill most annual and perennial plants with the exception of the perennial grasses. The grasses may be killed by disk-harrowing, as necessary, early in the season; two or three times, at 7- to 10-day intervals, may be required. Other equipment that may be used for mulch tillage includes large sweeps, spring-tooth field tillers, double-cut plows, heavy field cultivators equipped with moldboard shovels, or chisel-type plows (fig. 4). The implement to be used in the Eastern States will depend on the soil type and climatic and cropping conditions.

Planting row crops or drilling small grains and meadow seedings on fields with a mulch is not difficult if proper equipment is used (fig. 5). Disk-type openers work satisfactorily on small-grain drills. For row crops, most ordinary planters will do the job if attachments are added to keep the residue from collecting in front of the planter runner. A short iron bar projecting from the runner, double- or single-disk furrow openers, or

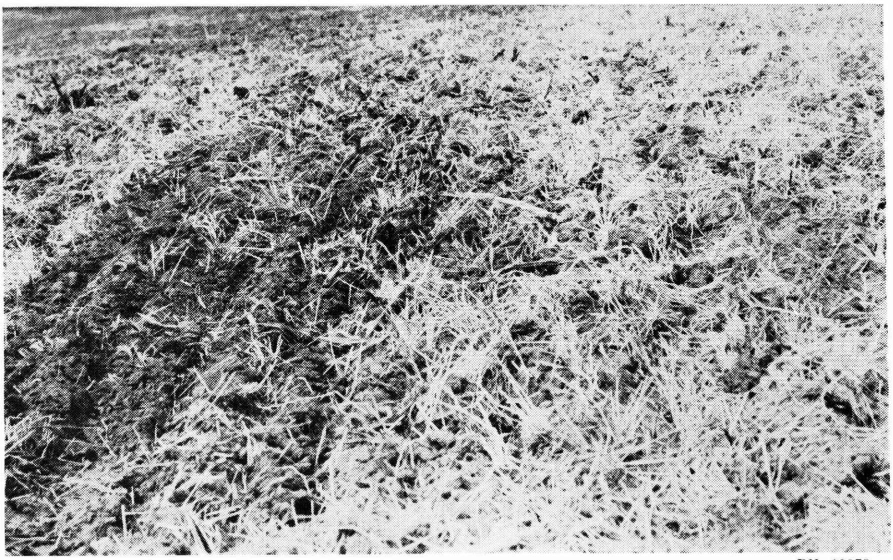

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Figure 3.—**Winter cover crop in South Carolina that is being prepared by mulch-tillage system for corn. The field of rye and vetch has been disk-harrowed twice and worked with a spring-tooth field tiller.**

shovel-type openers will work satisfactorily on conventional planters (fig. 6).

Some tillage implements leave the seedbed very loose or cloddy, and seed contact with the soil is poor. Under these conditions germination may be poor. Good stands can be obtained if the row crops are planted in the firm seedbed made by the tractor-wheel tracks (see fig. 8).

A cultivator with sweeps set almost flat does a good job of killing weeds and leaves plant residues on the surface for such row crops as corn (fig. 7). Tractor-mounted cultivators are well adapted to contours and terraced lands.

Although field conditions vary and no one system of mulch tillage can be given for all areas in the Eastern United States, the following step-by-step operation is given as an example for preparing a field for a row crop.

1. Disk-harrow sod crops with weighted, heavy-duty harrow with the disks set at full angle or use double-cut plow that inverts sod to 3-inch depth and loosens soil to 7 inches; disk-harrow or chop the residue of annual row crops.

2. Disk-harrow a second time if sod crops and weeds have not been killed.

3. About 10 days to 2 weeks later, crops may be planted without further preparation with a wheel-track planter equipped with disk openers and disk-fertilizer applicators. If a modified conventional planter is used, loosen soil with sweeps, spring-tooth field tiller, field cultivator, or other loosening tool (fig. 4, *A* and *C*). Smooth land with disk or spring-tooth harrow and plant, applying starter fertilizer and proper herbicide for crop.

4. Use rotary hoe for first cultivation. Corn may not need cultivation if long-lasting herbicides were applied at planting.

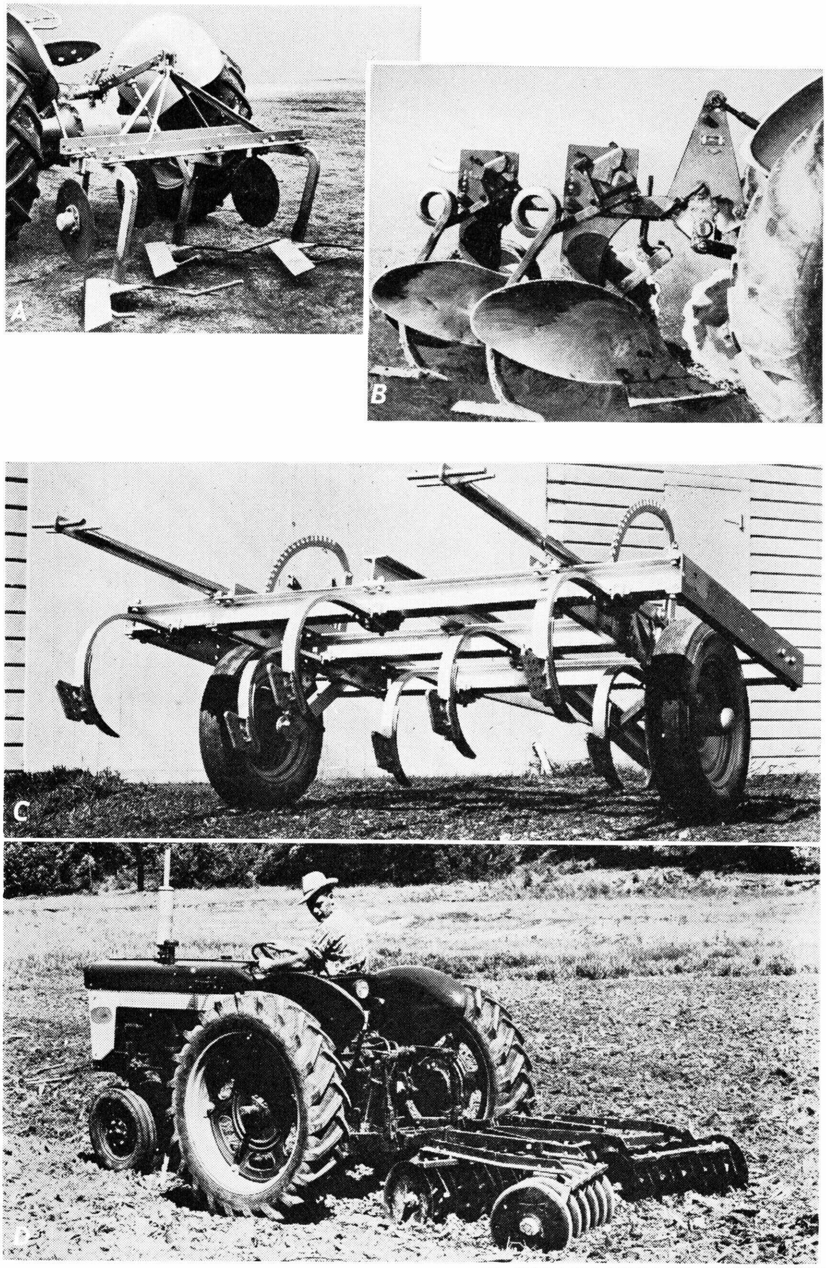

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Figure 4.—Implements used to prepare the soil for mulch-tillage system. A, Sweeps with rolling coulters loosen the soil, kill weeds, and leave the residue on the surface. The sweeps do not operate properly on rocky, compact soils and will not kill heavy grass sods. B, Double-cut plow inverts the upper few inches of soil while loosening the soil 7 to 8 inches and kills grass sods. A spring-tooth harrow will bring much of the residue to the soil surface. C, Chisel-type tiller will loosen the soil and kill sod if several trips are made across the field. The tiller tends to bury some of the residue, however. D, The disk-harrow can be used with the above implements to kill sod adequately and loosen the soil.

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Figure 5.—**Corn planted in South Carolina on a seedbed prepared by mulch-tillage system. Residue on the soil was grown as a rye-vetch winter cover crop.**

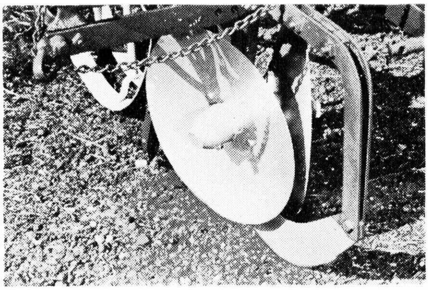

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Figure 6.—**Disk-furrow openers push the residue away from the planter runner and prevent the residue from clogging the planting furrow in a mulch-tillage system.**

5. Use sweep equipment, with sweeps set almost flat, for later cultivations.

Yields of mulch-tilled crops compare favorably with those by any other method of tillage. In some instances yields of mulch-tilled corn in Midwestern States were depressed. However, in the Southeast yields from mulch tillage were equal to or greater than yields from lands where residues were plowed under. For 8 years of a 10-year period in South Carolina, mulch-tilled corn produced 1 to 8 bushels per acre more than corn on plowed land.

Most research on mulch tillage has been with corn, but soybeans, cotton, and small grains also have been grown successfully on mulch-tilled lands. Weed control by mechanical methods is not always satisfactory, but in some cases weed control by herbicidal sprays is beneficial and economical.

In some areas, small quantities of nitrogen fertilizer, in addition to that required by the crops, may be needed while the plant residues are decomposing. However, in the Southeast, a starter fertilizer, in the amount recommended for the various States, is adequate to supply nitrogen requirements of most plants and micro-organisms during decomposition. In the Midwest and the Northeast, a fertilizer containing a higher percentage of nitrogen than that normally recommended by the various States will provide the nitrogen needs of both plants and micro-organisms.

Surface-Applied Mulches

Farm manure or straw spread on the soil protects it from erosion. To cover the soil adequately and to protect it from hard rains, 8 to 10 tons of wet strawy manure or about 2 tons of dry small-grain straw per acre are necessary. A spreader with a high-speed beater is recommended to insure thorough shredding of manure and to prevent large chunks from damaging corn plants. Corn rows should be either 40 inches apart or narrow enough that the spreader can straddle 2 rows. Since the corn may be damaged in applying the mulch, a higher rate of planting is desirable. If the mulch is straw or other materials low in nitrogen, extra nitrogen should be applied.

Although manure and plant-residue mulching may be done any time after planting the crop, cultivation tends to bury the mulch and reduce its effectiveness. Weeds

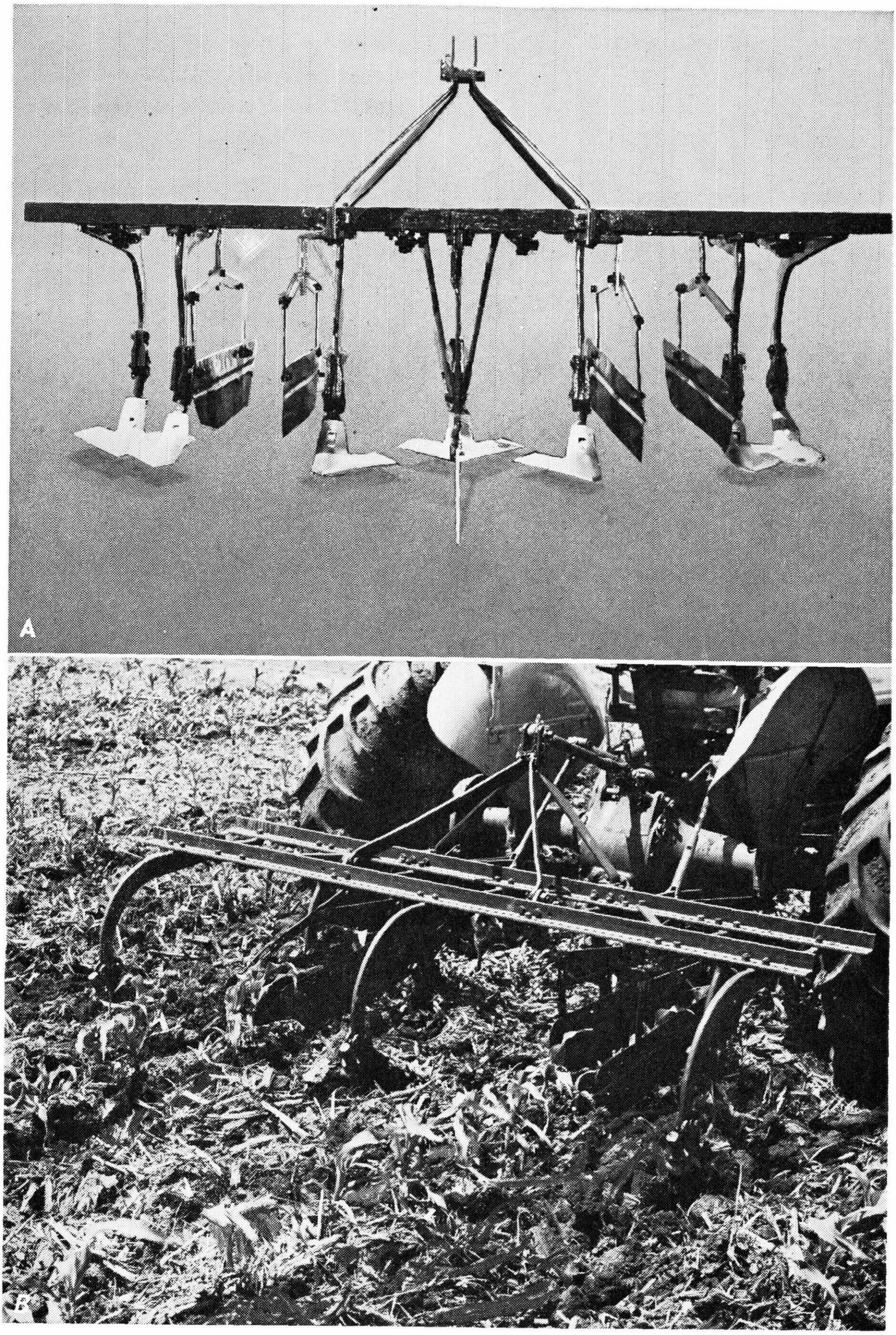

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Figure 7.—Cultivator with sweeps for corn: *A*, 12-inch sweeps are attached for the row middles and 12-inch sweeps with the inside wing cut off are set next to the corn rows; *B*, in cultivating, most of the weeds are killed and the chopped cornstalk residue is left on the surface.

should be controlled as early as possible and then the mulch should be applied. Rather than cultivate and thus bury the mulch, a herbicide can be used to control weeds.

Ohio has done pioneering work on surface-applied mulches on cornfields; other States have conducted more recent studies.

During a 7-year test in Ohio, corn yields on either straw- or manure-mulched plots averaged 104 bushels per acre, or an average of 5 bushels per acre more than when manure was plowed under. During the 4 years when the spring and summer rainfall was relatively low, the manure-mulched plots produced 8 bushels more corn per acre than yields on plots where the manure was plowed under. Straw-mulched plots with no manure plowed under produced 10 bushels more. Periodic determinations showed that surface-mulched soil had more moisture than the nonmulched soil.

At Shenandoah, Iowa, in the drought year 1956, mulching the soil with 2 tons of oat straw at planting time and after the first cultivation, produced 14 and 20 bushels more corn per acre, respectively, than on nonmulched soil. In North Carolina during 1944–47, corn yields of 8 experiments were increased by an average of 21 bushels per acre, owing to an application of mulch at the last cultivation. In most cases 3 tons of wheat straw per acre were applied. As large quantities of fertilizer were applied to both the mulched and nonmulched soils, investigators concluded that the increased yield was due to less evaporation from the mulched soil.

In a test of Maryland tobacco, straw mulch applied at the rate of 4 to 6 tons per acre did not affect the yield or quality of the crop during 4 years of favorably distributed rainfall. During 2 years with excessive rainfall early in the season, the straw mulch greatly depressed tobacco yields per acre. During a dry season, the mulch increased tobacco production. For the 7-year period 1940–46, the mulch decreased the total dollar value of the crop about 5 percent.

Plowing Down Crop Residues

Turning under residues is the conventional system of tillage that has been practiced for years. Field reports in the Southeast indicate that yields have been increased considerably by turning under grass and legume sods. The effects of some of these residues appear to extend over several years.

In a test in Iowa, rates of 0 to 8 tons per acre of cornstalks, oat straw, sawdust, alfalfa hay, or grass hay were incorporated each year for 5 consecutive years in Marshall soil, and corn was grown each year. Yields were not significantly different from those where no residues were incorporated. Generally, yields of crops grown by plowing under residues have been about equal to those by mulch tillage.

Plowing under large quantities of plant residues 10 days to 2 weeks prior to planting may facilitate planting operations. Disk-harrowing after plowing will loosen the soil around the roots of living plants and break large soil clods. Green-manure crops will die in this period, and some of the residues will decompose.

Stalk or residue choppers may be used to chop thoroughly living or dead plants before plowing. This will prevent the residues from raking or balling up when the soil is plowed. Disk plows will cut

through most residues. However, inadequate chopping will cause residues like vetch and rye to mat and aggravate plowing difficulties when moldboard plows are used. Planting is also easier if residues are chopped into small pieces.

Plowing down growing meadow and cover crops and immediately planting corn with a wheel-track planter or other minimum-tillage equipment has produced good yields in the Midwest and the Southeast (fig. 8). This is a modification of the plow-plant procedure and has proved to be almost as effective as mulch tillage in reducing runoff and erosion in the Piedmont area of South Carolina. Wheel-track planting leaves the row middle loose without compaction—usually caused by wheels of equipment—and thus improves aeration. Cultivation of the corn is unnecessary when the required plant nutrients and a long-lasting herbicide are applied at planting time. Corn, following a cover crop of vetch and rye, yielded somewhat more than that grown on land where no cover crop preceded the corn. Cotton, soybeans, and sorghum have also been grown by the plow-plant procedure in the Southeast.

The following outline gives a step-by-step procedure for row crops when crop residues are plowed under.

For conventional methods:

1. Chop residues if desirable.
2. Plow.
3. Disk-harrow.
4. About 10 days after initial land preparation, smooth with harrow if necessary.
5. Plant with conventional-type planter, applying starter fertilizer and proper herbicide.
6. Cultivate as necessary.

For wheel-track planting:

1. Chop residues if desirable.
2. Plow.
3. Plant immediately with a wheel-track planter, applying starter fertilizer and herbicide.
4. Cultivate as necessary.

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***Figure 8.*—An experimental wheel-track planter planting corn after minimum tillage. Disk fertilizer-applicators and small runner-type furrow-openers follow the rear tractor wheels. A granular herbicide is applied in a band about 14 inches wide over the row. Corn, soybeans, grain sorghum, and cotton (with slight machine modifications) can be planted with this equipment.**

Most row crops will need cultivation, but corn can be grown without it if chemical weed control is used that is effective during the growing season. Fertilizer practices for crops when residues are plowed under are the same as those for mulch tillage. If large amounts of low-nitrogen residues are plowed under, more nitrogen may be needed for the crop than if no residues were present.

Selecting a Method of Handling Residues

Whether crop residues should be left on the soil surface or incorporated with the soil depends on the crop to be planted; soil, land slope, and cropping conditions; available equipment; and other factors. Mulch tillage and contour farming should be practiced on hilly, erosive land, especially in areas where rainfall may be intense. Mulches reduce runoff and depress evaporation from the soil surface, and this conservation of water may be the difference between a good yield and and a poor yield. On soils requiring drainage, the insulating and reflecting effects of a mulch cause a lower soil temperature and slow drying by evaporation, which may retard plant growth and development in early spring. Methods for mulch tillage are usually, but not always, cheaper than those for conventional plowing methods.

Handling plant residues by plowing under and disk-harrowing does not provide as much protection to the land from erosion as that from mulch tillage. On some lands that are almost level, drainage problems may overshadow erosion hazards. Under these conditions, plowing under residues would be more feasible than mulch tillage. In some areas, plowing is desirable in the control of insects. Cotton and corn lands are plowed sometimes in an effort to reduce the cotton boll weevil and corn borer infestations.

After residues are turned under, the plow-plant method, using wheel-track planting and minimum tillage, will reduce erosion and runoff to a considerable extent. This method is adapted to hilly, rolling, and gently sloping to almost level lands. Several equipment manufacturers are producing implements that can be used satisfactorily. However, trailing planters can be developed by most farmers to plant in the tracks of the rear tractor wheels. The objective is to leave row middles "clean" but rough without wheel tracks. This may cause faster drying of the soils, but it provides better soil aeration. If cultivations can be eliminated by use of chemical weed control, the soil surface will be relatively rough throughout the growing season. The mechanical effect of the rough surface in retarding the flow of and impounding the water will provide more moisture for plant use than the smooth surface of the conventional plow tillage method.

A system of handling residues can be developed for any field and for any crop. The importance of utilizing the residues in the most efficient manner so that maximum benefits may be derived from them cannot be overemphasized. The system selected for a specific field and crop must be one that will result in economical production and will conserve soil, water, and plant nutrients.

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